Tutorial – 2

1. Water in a 150-L closed, rigid tank is at 100°C, 90% quality. The tank is then cooled to −10°C. Calculate the heat transfer during the process. Ans. -263.3 kJ

2. A 10-L rigid tank contains R-22 at −10°C, 80% quality. A 10-A electric current (from a 6-V battery) is passed through a resistor inside the tank for 10 min, after which the R-22 temperature is 40°C. What was the heat transfer to or from the tank during this process? Ans: -23.5 kJ

3. A piston/cylinder arrangement contains 1 kg of water, shown in Fig. The piston is spring loaded and initially rests on some stops. A pressure of 300 kPa will just float the piston and, at a volume of 1.5 m³, a pressure of 500 kPa will balance the piston. The initial state of the water is 100 kPa with a volume of 0.5 m³. Heat is now added until a pressure of 400 kPa is reached.

a. Find the initial temperature and the final volume. Ans: 99.6 , 1m³
b. Find the work and heat transfer in the process and plot the P–V diagram. Ans: 175, 2434 kJ

4. A piston/cylinder arrangement B is connected to a 1-m³ tank A by a line and valve, shown in Fig. Initially both contain water, with A at 100 kPa, saturated vapor and B at 400°C, 300 kPa, 1 m³. The valve is now opened and, the water in both A and B comes to a uniform state.
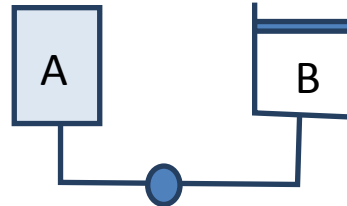
a. Find the initial mass in A and B. Ans. .5903, .9695 kg
b. If the process results in $T_2 = 200°C$, find the heat transfer and work. Ans : -264.82, -484.7kJ

5. Consider the same setup and initial conditions as in the previous problem. Assuming that the process is adiabatic, find the final temperature and work. Ans: 352C, -152.1 kJ

6. A vertical cylinder fitted with a piston contains 5 kg of R-22 at 10°C, shown in Fig. Heat is transferred to the system, causing the piston to rise until it reaches a set of stops at which point the volume has doubled. Additional heat is transferred until the temperature inside reaches 50°C, at which point the pressure inside the cylinder is 1.3 MPa.
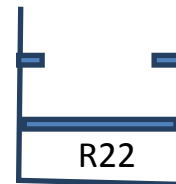
a. What is the quality at the initial state? Ans: .2735
b. Calculate the heat transfer for the overall process. Ans: 34.1 , 757.6kJ

7. Consider the system shown in Fig. Tank A has a volume of 100 L and contains

saturated vapor R-134a at 30°C. When the valve is cracked open, R-134a flows slowly into cylinder B. The piston mass requires a pressure of 200 kPa in cylinder B to raise the piston. The process ends when the pressure in tank A has fallen to 200 kPa. During this
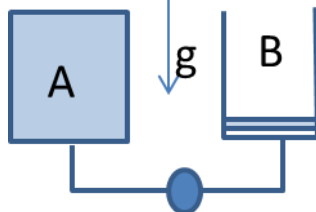

process heat is exchanged with the surroundings such that the R-134a always remains at 30°C. Calculate the heat transfer for the process. Ans: 101.26 kJ

8. A cylinder/piston arrangement contains 5 kg of water at 100°C with $x = 20\%$ and the piston, $mP = 75$ kg, resting on some stops, similar to Fig. P5.35. The outside pressure is 100 kPa, and the cylinder area is $A = 24.5$ cm^2. Heat is now added until the water reaches a saturated vapor state. Find the initial volume, final pressure, work, and heat transfer terms and show the P–v diagram. Ans: 400kPa, 254.1 kJ, 8840kJ
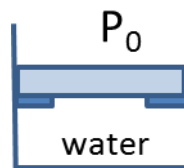
9. A 10-m high cylinder, cross-sectional area 0.1 m^2, has a massless insulated piston at the bottom with water at 20°C on top of it, shown in Fig. P5.79. Air at 300 K, volume 0.3 m^3, under the piston is heated so that the piston moves up, spilling the water out over the side. Find the total heat transfer to the air when all the water has been pushed out. Ans: 169.8kPa, 220.7 kJ
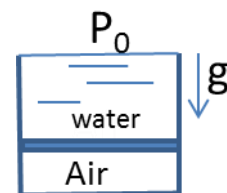
10. A cylinder fitted with a frictionless piston contains R-134a at 40°C, 80% quality, at which point the volume is 10 L. The external force on the piston is now varied in such a manner that the R-134a slowly expands in a polytropic process to 400 kPa, 20°C. Calculate the work and the heat transfer for this process. Ans: 14.2, 27.6 kJ

11. Water at 150°C, quality 50% is contained in a cylinder/piston arrangement with initial volume 0.05 m3. The loading of the piston is such that the inside pressure is linear with the square root of volume as $P = 100 + CV^{0.5}$ kPa. Now heat is transferred to the cylinder to a final pressure of 600 kPa. Find the heat transfer in the process.   Ans: 284 KJ

12. A spherical balloon initially 150 mm in diameter and containing R-12 at 100 kPa is connected to a 30-L uninsulated, rigid tank containing R-12 at 500 kPa. Everything is at the ambient temperature of 20°C. A valve connecting the tank and balloon is opened slightly and remains so until the pressures equalize. During this process heat is exchanged so the temperature remains constant at 20°C and the pressure inside the balloon is proportional to the diameter at any time. Calculate the final pressure and the work and heat transfer during the process. Ans: .262 Mpa, 6.11 kJ, 8.52 kJ

13. A cylinder fitted with a frictionless piston contains 0.2 kg of saturated (both liquid and vapor present) R-12 at -20°C. The external force on the piston is such that the pressure inside the cylinder is related to the volume by the expression:
     $P = - 47.5 + 4.0 \times V^{1.5}$, kPa and L

Heat is now transferred to the cylinder until the pressure inside reaches 250 kPa.
Calculate the work and heat transfer. Ans: .835, 20.75 kJ

14. A frictionless, thermally conducting piston separates the air and water in the cylinder
    shown in Fig. The initial volumes of A and B are each 500 L, and the initial
pressure on each side is 700 kPa. The volume of the liquid in B is 2% of the volume of B at this
state. Heat is transferred to both A and B until all the liquid in B evaporates. Notice that $P_A = P_B$
and $T_A = T_B = T_{sat}$ through the process and iterate to find final pressure and then determine the
heat transfer. Ans: 2.57 Mpa, 17383 kJ, W_A= -441.6 kJ, Q_A = -321.6 kJ

A	B
Air	water